Volume 6 FEBRUARY 10, 1931 Number 1

BULLETIN

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OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM

FOR THE

NEW YORK MEETING

FEBRUARY 26–28, 1931

JOINT MEETING

WITH THE

OPTICAL SOCIETY OF AMERICA

AT THE MUSEUM OF SCIENCE AND INDUSTRY

AND

COLUMBIA UNIVERSITY

For Program of session of the Optical Society see Pages 4 to 13.
For Program of sessions of the Physical Society see Pages 14 to 24.

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SIX ISSUES EACH YEAR

The American Physical Society

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BULLETIN

of the

AMERICAN PHYSICAL SOCIETY

Published six times per year

Subscription price: $5.00 per year.

The Bulletin of the American Physical Society is published six times a year during the months of February, April, June, November (2 issues), and December at 450 Ahnaip Street, Menasha, Wisconsin.

(Note: The subscription price of the Bulletin has been raised from $1.00 to $5.00 per year with single copies at $1.00 each.)

Address correspondence to Secretary W. L. Severinghaus, Columbia University, New York, N.Y.

Entered at the post office at Menasha, Wisconsin, as second class matter.

FEBRUARY 10, 1931 Vol. 6, No. 1

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

NEW YORK MEETING, FEBRUARY 26–28, 1931

JOINT MEETING WITH THE OPTICAL SOCIETY OF AMERICA

The 169th regular meeting of the American Physical Society will be held in New York City on Thursday, Friday, and Saturday, February 26–28, 1931, as a joint meeting with the Optical Society of America.

The sessions on Thursday will be held under the auspices of the Optical Society at The Museum of Science and Industry (Museums of the Peaceful Arts), 220 East 42nd Street. These sessions will be devoted to consideration of color problems. The Museum will have at the same time a very extensive Color Exhibition.

The sessions on Friday and Saturday for both the Physical Society and the Optical Society will be held at Columbia University. The Friday morning, Saturday morning and Saturday afternoon sessions will be held in the Physics Laboratories on 120th Street east of Broadway (entrance at 119th Street and Broadway).

Joint Session. On Friday afternoon at 2:30 o'clock there will be a joint session of the two Societies in the McMillin Theater of Columbia University, northeast corner of 116th Street and Broadway (entrance on Broadway). This session will be a Symposium on "Physical Problems Related to the Biological Effects of Radiant Energy." The President of the Optical Society, Dr. L. A. Jones, of the Eastman Kodak Company, will preside.

Dinner. On Friday evening at 6:30 o'clock there will be a joint dinner for the members of the two Societies and their friends at the Hotel Commodore, Lexington Avenue and East 42nd Street. The president of the Physical Society, Dr. W. F. G. Swann of the Bartol Research Foundation, will preside. The price of this dinner will be $2.50 per plate. Tickets will be on sale both at the Museum of Science and Industry and at the Physics Laboratories, Columbia University. Reservations should be made as early as possible and not later than Friday at noon.

After the dinner there will be an opportunity to visit the Color Exhibition at the Museum of Science and Industry.

Luncheon and Dinner. On Friday and Saturday luncheon may be had at the Columbia University Men's Faculty Club (corner 117th Street and Morningside Drive). Further announcement will be made at the Friday and Saturday sessions.

Abstracts. Titles and abstracts of papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts of the Physical Society papers will be published in the Physical Review, and those of the Optical Society papers in the Journal of the Optical Society of America. Authors should send corrections to the editors of the respective journals.

W. L. SEVERINGHAUS, *Secretary American Physical Society*
Columbia University, New York, N. Y.

February 10, 1931.

CALENDAR

Thursday sessions will be held at the Museum of Science and Industry.

Thursday morning

10:00 o'clock; Museum: Optical Society Papers 1–7.

Thursday afternoon

2:00 o'clock; Museum: Optical Society Papers 8–12.

Friday sessions will be held at Columbia University

Friday morning

10:00 o'clock; Physics Lab: Room 428: Optical Society Papers 13–17.
10:00 o'clock; Room 401: Physical Society Papers 1–14.
10:00 o'clock; Room 329: Physical Society Papers 15–20.

Friday afternoon

2:30 o'clock; McMillin Theater: Joint session of the two Societies: Symposium.

Friday evening

6:30 o'clock; Hotel Commodore: Joint dinner of the two Societies.

Saturday sessions will be held at Columbia University.

Saturday morning

10:00 o'clock; Physics Lab: Room 428: Optical Society Papers 21–27.
10:00 o'clock; Room 401: Physical Society Papers 24–33.

Saturday afternoon

2:00 o'clock; Room 428: Optical Society Papers 28–34.
2:00 o'clock; Room 401: Physical Society Papers 34–40.

Other meetings of the Physical Society during the current season are as follows:

170. Washington Meeting. April 30, May 1 and 2, 1931.
171. June 16–20, 1931. Pasadena, with the A. A. A. S.

NOTE: The June meeting previously announced to be held at Princeton, has been withdrawn.

CALL FOR INFORMATION

The Council of the American Physical Society desires to promote closer relations between local and national groups interested in physics or in any of its applications. In order to proceed intelligently it has appointed a committee to collect information regarding such groups and to report possible ways and means for cooperation among them and between each of them and the American Physical Society as a whole.

To expedite this work every member of the Society is urged to send at once to the chairman of the committee, (L. W. McKeehan, Yale University, New Haven, Connecticut) such information as he can concerning groups he belongs to or knows about. The committee is interested in the size of each group, its avowed purposes, the character of its activities, the frequency of and usual attendance at its meetings, the names and addresses of its officers, the method by which it is supported, and plans or suggestions for desirable changes of any sort. Where several members of a group receive this call the committee requests that no one assume without proof that another member has responded.

PROGRAM

Thursday Morning at 10 o'clock
Museum of Science and Industry

Session of

THE OPTICAL SOCIETY OF AMERICA

OFFICERS

President, Loyd A. Jones, Eastman Kodak Company
Vice-President, E. C. Crittenden, Bureau of Standards
Secretary, L. B. Tuckerman, Bureau of Standards
Treasurer, Adolph Lomb, Bausch and Lomb Optical Company
Council: Consists of the above officers, P. D. Foote, F. K. Richtmyer, A. H. Compton, I. C. Gardner, P. E. Klopsteg, E. D. Tillyer.

INVITED PAPERS ON

INDUSTRIAL COLOR STANDARDS

1. **G. F. A. Stutz**
Fundamental Research Division, New Jersey Zinc Company
REFLECTANCE MEASUREMENTS IN THE PAINT INDUSTRY

2. **Carl Z. Draves**
Technical Laboratory, E. I. du Pont de Nemours and Company
SPECTROPHOTOMETRIC MEASUREMENTS IN THE DYESTUFFS INDUSTRY

3. **W. B. Van Arsdel** **Research Department, The Brown Company**
COLOR SPECIFICATION IN THE PULP AND PAPER INDUSTRY

4. **W. D. Appel** **Bureau of Standards**
COLOR PROBLEMS IN THE TEXTILE INDUSTRY

5. **A. E. O. Munsell** **Munsell Research Laboratory**
THE MUNSELL BOOK OF COLOR

6. **M. Rea Paul, Research Laboratories** **National Lead Company**
THE DICTIONARY OF COLOR

7. **Margaret H. Rorke Textile Color Card Association of the United States, Inc.**
THE WORK OF THE TEXTILE COLOR CARD ASSOCIATION

Thursday Afternoon at 2 o'clock
Museum of Science and Industry

INVITED PAPERS ON

SPECTROPHOTOMETRY AND THE USE OF PHOTOELECTRIC METHODS IN COLORIMETRY

8. **Herbert E. Ives and E. F. Kingsbury** **Bell Telephone Laboratories**
THE APPLICABILITY OF PHOTOELECTRIC CELLS TO COLORIMETRY

9. K. S. Gibson — **Bureau of Standards**

SPECTROPHOTOMETRY AT THE BUREAU OF STANDARDS

10. Paul McMichael and Monroe Barnard — **American Photoelectric Corp.**

SOME COMPARATIVE SPECTROPHOTOMETRIC MEASUREMENTS

11. P. J. Mulder and Joseph Razek — **University of Pennsylvania**

THE RAZEK-MULDER COLOR ANALYZER: PART I. GENERAL DESCRIPTION INCLUDING RECENT IMPROVEMENTS. PETER J. MULDER, PART II. DISCUSSION AND EVALUATION OF ERRORS IN THE INSTRUMENT. JOSEPH RAZEK.

12. Irwin G. Priest — **Bureau of Standards**

SOME REMARKS ON CURRENT PROPOSALS RELATIVE TO THE APPLICATION OF VARIOUS PHOTOELECTRIC INSTRUMENTS TO PRACTICAL PROBLEMS OF COLOR SPECIFICATION.

Thursday Evening at 8 o'clock

Representatives of organizations invited to participate in the Preliminary Conference on Organization of an Inter-Society Committee on Color Specifications will meet at the Museum of Science and Industry.

Friday Morning at 10 o'clock

Columbia University, Physics Laboratory, Room 428

(For simultaneous sessions of the Physical Society, Rooms 401 and 329, see Program pages 14–18)

INVITED PAPERS ON

COLOR SPECIFICATIONS

13. Irwin G. Priest — **Bureau of Standards**

FUNDAMENTAL PRINCIPLES OF COLOR SPECIFICATION

14. Deane B. Judd — **Bureau of Standards**

CHROMATIC SENSIBILITY TO STIMULUS DIFFERENCES, AND TOLERANCES IN COLOR SPECIFICATIONS

CONTRIBUTED PAPERS

15. H. P. Gage — **Corning Glass Works**

COLORIMETRIC EFFICIENCY OF RED GLASS

With the advent of colorimetric specifications for colored signal glasses such specifications have been promulgated as "red glass transmitting 40 percent of the incident light" and "red glass transmitting 9 percent of the incident light and having a dominant hue of .640μ."

Assume a red glass transmitting 100 percent for all wave lengths greater than the cut-off point and zero for all wave lengths shorter, the luminous transmission would be the sum of all terms in a luminosity curve for wave lengths greater than the cut-off point, divided by the sum of all terms. The luminosity curve must be for the light source used, as for example Acetylene at 2360°K, and preferably one in which the sum of the terms is 1.00. In a similar way the trilinear coordinates of the same light source for all wave lengths greater than the cut-off point. Curves are drawn for cut-off point as abscissae against luminous transmission and against percent red and against dominant wave length. The theoretical transmission of a perfect red glass of given dominant wave length can then be compared with that found by spectrophotometric analysis of an actual red glass.

Bibliography:

Report on Colorimetry, J.O.S.A. & R.S.I., VI, p. 527, Aug. 1922.

J. F. Skogland, Miscellaneous Publications, Bureau of Standards (No. 86) tables, p. 19.

H. P. Gage, Practical Considerations in the Selection of Standards for Signal Glass in the United States, Proceedings ICI, Table p. 856.

10 min.

16. Dorothy Nickerson — **Bureau of Agricultural Economics**
U. S. Department of Agriculture

A Colorimeter for Use with Disc Mixture

The colorimeter to be described is one developed with the cooperation of Mr. Carl W. Keuffel. It measures either a large or a small area and integrates the color of a surface even though it may be highly variegated.

The method of measurement, by the use of disc mixture of Munsell papers, permits the expression of results in terms which adequately approximate the psychological atttributes: hue brilliance and chroma (or saturation). If it seems preferable, measurements may be made through color filters to give tri-chromatic data, or the colorimeter may be transformed into a simple analyser by the use of filters transmitting a narrow band of wave lengths. In such cases, black and white discs of known reflection are used to make the photometric match.

10 min.

17. Dorothy Nickerson — **Bureau of Agricultural Economics**
U. S. Department of Agriculture

Color Measurements in Psychological Terms

With the colorimeter previously described and with one somewhat similar, measurements have been made on thousands of samples of agricultural products. Many of them were made with a view either to establishing standards for the grade factors of color or to calibrating the color in existing standards. Data will be given to illustrate how this method answers the purpose. Data will also be presented regarding the precision with which such measurements are made.

10 min.

Friday Afternoon, 2:30 o'clock
McMillin Theatre, Columbia University

SYMPOSIUM

Joint Session of the American Physical Society and the Optical Society of America.

INVITED PAPERS ON

PHYSICAL PROBLEMS RELATED TO THE BIOLOGICAL EFFECTS OF RADIANT ENERGY

18. Brian O'Brien — **Institute of Applied Optics, University of Rochester**

Some Physiological Effects of Light

19. Harvey B. Lemon — **The University of Chicago**

The Spectra and Anti-Rachitic Potency of Various "Therapeutic" Lamps

20. Harold W. Webb — **Columbia University**

Methods of Measuring Radiant Energy

Saturday Morning, 10 o'clock
Columbia University, Physics Laboratory, Room 428

(For simultaneous session of the Physical Society, Room 401, see Program pages 19–21)

CONTRIBUTED PAPERS

21. Selig Hecht — **Columbia University**

Interrelations Among Various Aspects of Color Vision

The data of color vision which include measurements of the luminosity of the spectrum, color mixture, least perceptible colorimetric purity, hue discrimination, and relative luminosities of

spectral complementaries, have each been secured on different eyes. Therefore theoretical comparisons among the data cannot be rigorously exact. However, one can construct theoretical mechanisms (a) that yield all the visual functions in approximate agreement with data; or (b) that yield some functions in perfect agreement, and the rest in approximate agreement with data. Since all visual functions are interrelated, the choice of function for approximate or precise derivation is arbitrary.

In terms of certain ideas three cone primaries were suggested, whose spectral distributions were planned to yield an exact agreement with measurements of hue discrimination, least perceptible colorimetric purity, and the luminosity of the spectrum. They gave the relative luminosities of spectral complementary colors in close approximation to data. However, they were made to agree only very roughly with standard color mixture data, because the importance of these data seemed exaggerated.

To show that the ideas involved are unaffected by such very rough agreement, several sets of cone primaries have been prepared. One set yield exactly the O.S.A. excitations, and a normal visibility curve; a hue discrimination function which shows the same form, and the same location of maxima and minima as the date; a minimum perceptible colorimetric purity function of the same form as the data, though differing in detail; and the relative luminosities of spectral complementaries essentially as before.

Another set of cone primaries furnish an exact agreement with the hue discrimination data, and a normal visibility curve; color mixture curves which, though not exactly corresponding to the O.S.A. curves, agree with them to the extent shown by the individual measurements which formed the basis of the O.S.A. curves; and an adequate description of spectral complementary luminosities.

Other cone primaries have been prepared which do similar things. Their preparation and adequacy is determined largely by time and patience. The ideas involved remain the same and may be tested by determining the different visual functions on the same eye.

30 min.

The present paper will appear in full in J.O.S.A.

22. Deane B. Judd **Bureau of Standards**

COMPARISON OF DISTRIBUTION CURVES EMBODYING WRIGHT'S RECENT RESULTS WITH THE O.S.A. "EXCITATION" CURVES

Wright[1] has recently reported for 10 observers the trilinear coordinates of the spectrum referred to the colors corresponding to 460, 530, and 650 mμ, respectively, as primaries, and to the N. P. L. standard white as basic stimulus. Furthermore these results are so adjusted as to refer to the average macular pigmentation of 36 normal observers. Since the final average is much more securely founded than the average embodied in the O.S.A. "excitation" curves which have been in provisional use for nearly 10 years, it is of interest to compare the two sets of curves. Accordingly, distribution curves have been derived which embody Wright's results and which embody the same visibility function as the O.S.A. "excitation" curves. Furthermore, since these curves give the distributions of the primary colors of the O.S.A. "excitation" curves throughout the spectrum of Abbot-Priest sunlight and have the same areas, they are directly comparable with the O.S.A. "excitation" curves referred to Abbot-Priest sunlight as prime-basic stimulus.

A comparison of these two sets of curves reveals a degree of correspondence which is rather surprising in view of the somewhat insecure foundation of the O.S.A. "excitation" curves. The discrepancies which do appear would be considerably decreased if the "eye" specified by the O.S.A. "excitation" curves were changed to refer to observation through a yellow filter about half as dense as that found by Sachs[2] to be the equivalent of the average human macula lutea. This change in pigmentation is well within the limits of normal variation.

It is concluded that there is little urge to supplant the O.S.A. "excitation" curves for colorimetric computation on the ground that they do not represent with sufficient accuracy average, normal vision; the gain in accuracy to be obtained by substitution of a set of distribution curves

[1] W. D. Wright, A Re-Determination of the Trichromatic Coefficients of the Spectral Colours, Trans. Opt. Soc. *30*, pp. 141–164; 1928–29.

[2] M. Sachs, Ueber die specifische Lichtabsorption des gelben Fleckes der Netzhaut, Pflüger's Arch., *50*, pp. 574–586; 1891.

embodying Wright's results is of too little practical importance to compensate adequately for the inconvenience of changing from one standard set of curves to another.

20 min.

23. Deane B. Judd — **Bureau of Standards**

EXTENSION OF THE O.S.A. "EXCITATION" CURVES TO INTERVALS OF ONE MILLIMICRON BY FIFTH-DIFFERENCE OSCULATORY INTERPOLATION.

It has been shown that[1] the O.S.A. "excitation" curves do not differ seriously from distribution curves embodying the much more extensive and reliable measurements by Wright. This proof of the substantial accuracy of the curves which have been used tentatively for colorimetric computation for nearly 10 years suggests the likelihood of their continued use for, perhaps, a similar period.

Considerable inconvenience in past attempts to derive by means of these curves the dominant wave length and colorimetric purity of color stimuli has resulted because of difficulty in obtaining reproducible interpolated values; for example, the large errors found by Priest[2] in computed values of purity were shown to be due to interpolation difficulties by Judd[3] who described computational procedures for minimizing the result of errors of interpolation.

In order to make possible the reproducible computation of dominant wave length and colorimetric purity, the O.S.A. "excitation" curves have been extended to intervals of one millimicron between 410 and 670 mμ by the method of osculatory interpolation. Each curve is represented as a series of parabolas of the fifth degree which join at the specified values (at every 10 mμ) so as to have a common first derivative and a common second derivative at the junction point. Sufficient accuracy has been maintained in the computation of these interpolated values to yield a basis for the computation of dominant wave length reproducible to one one-hundredth of a millimicron.

10 min.

[1] Comparison of Distribution Curves Embodying Wright's Recent Results with the O.S.A. "Excitation" Curves, this program.

[2] Irwin G. Priest, The Computation of Colorimetric Purity, J.O.S.A. & R.S.I., *9*, p. 517; 1924.

[3] Deane B. Judd, The Computation of Colorimetric Purity, J.O.S.A. & R.S.I., *13*, pp. 133–152; 1926.

24. Deane B. Judd — **Bureau of Standards**

A NEW SET OF DISTRIBUTION CURVES FOR USE IN COLORIMETRIC COMPUTATION.

Although the O.S.A. "excitation" curves represent average, normal vision with fair accuracy[1] they possess a number of minor defects which lead to considerable inconvenience when they are used in colorimetric computation. It is possible that the time is now ripe for the correction of these defects. Accordingly a set of distribution curves has been derived from data (Wright and Gibson-Tyndall) published since the compilation of the O.S.A. "excitation" curves which have the following advantages for use in colorimetric computation:

(A) The new set of curves embodies the macular pigmentation corresponding to an average of 36 observers; the O.S.A. curves, to 2 or 3 observers.

(B) The new set of curves embodies the mixture data corresponding to an average of 10 observers, each of which yielded nearly identical results when the individual differences due to macular pigmentation had been eliminated; the O.S.A. curves embody the mixture data of 3 observers; part of the observations of one observer, which disagreed widely from those of the other two, were rejected.

(C) The new curves are smooth; the O.S.A. curves are somewhat irregular and require special treatment for finding interpolated values.[2]

(D) The new set of curves embodies the visibility function adopted as standard by international agreement; the O.S.A. curves are only approximately consistent with the standard visibility.[3]

(E) The luminosity coefficients referrring to the new set of curves are: $L_r=1, L_g=0, L_b=0$; those referring to the O.S.A. curves are: $L_r=0.370$, $L_g=0.617$, $L_b=0.012$. It is evident that any computations involving the use of luminosity coefficients (such as computation of transmission, reflectance or colorimetric purity) will be considerably simplified if the new set of distribution curves be substituted for the O.S.A. "excitation" curves.

The only disadvantage in supplanting the O.S.A. curves by the new set of curves is the rather considerable inconvenience entailed by the change, itself.

10 min.

[1] Comparison of Distribution Curves Embodying Wright's Recent Results with the O.S.A. "Excitation" Curves, this program.

[2] Extension of the O.S.A. "Excitation" Curves to Intervals of One Millimicron by Fifth-Difference Osculatory Interpolation, this program.

[3] Proc. Int. Commission on Illumination, 6th meeting, Geneva, pp. 67 and 232; July, 1924.

25. Deane B. Judd — Bureau of Standards

EXTENSION OF THE STANDARD VISIBILITY FUNCTION TO INTERVALS OF ONE MILLIMICRON BY THIRD-DIFFERENCE OSCULATORY INERPOLATION.

The two empiric representations (Tyndall-Gibson[1] and Walsh[2]) of the visibility of radiant energy yield curves which fail to pass exactly through the values at every 10 mμ adopted as standard;[3] hence, they can not serve as means of obtaining interpolated values. By the method of osculatory interpolation the visibility function is represented as a series of parabolas of the third degree which join at the specified values so as to have a common first derivative at the junction point. The discontinuities in derivatives of higher order which exist at the junction points are sufficiently small to be of no consequence.

5 min.

[1] E. P. T. Tyndall and K. S. Gibson, Visibility of Radiant Energy Equation, J.O.S.A. & R.S.I., *9*, p. 403; 1924.

[2] J. W. T. Walsh, Visibility of Radiant Energy Equation, J.O.S.A. & R.S.I., *11*, pp. 111–112; 1925.

[3] Proc. Int. Commission on Illumination, 6th meeting, Geneva, pp. 67 and 232; July, 1924.

26. Loyd A. Jones and R. E. Burroughs — Kodak Research Laboratories

THE ACTION OF LOW SPEED ELECTRONS ON PHOTOGRAPHIC EMULSIONS

Electrons from a heated cathode are accelerated by a potential V to an anode containing a slit. The electron beam passing through the slit was focused by a magnetic field on the photographic emulsion being studied.

The experiments performed brought out the following facts. No electron impacts were recorded when the electron beam was not distinctly defined by a visible radiation from the residual gas. The lowest voltage electrons recorded in each case was the lowest voltage electron that would produce a visible radiation in the residual gas of the electron tube. The lowest potential V which would cause the electron to produce a photographic blackening was determined by the composition of the residual gas and its pressure and in no way indicated that it was related to a characteristic of the photographic emulsion. The conclusion is drawn that the exposure produced on a photographic emulsion is not due to the sensitive grain receiving the electron's energy directly, but is due to the radiation excited by impacts of the electrons with the residual gas.

Bibliography:

K. Cole, Phys. Rev., Vol. 28, pp. 781–792, Oct., 1926.
P. H. Carr, R.S.I., Vol. 1, p. 711, Dec., 1930.

The present paper will appear in full in J.O.S.A.

10 min.

27. Fred E. Wright — Geophysical Laboratory

OPTICAL METHODS FOR REDUCING THE EFFECTS OF PHOTOGRAPHIC PLATE GRAIN

In the measurement of the positions of spectral lines or star images or other details on photographic plates the large silver grains of the negative are disturbing elements detrimental to accuracy. The obtrusiveness of these grains can be decreased by causing the image points of adjacent grains to overlap and merge. Dr. J. A. Anderson of Mt. Wilson Observatory recently accomplished this object by mounting a cylindrical lens above the objective of the observing microscope, thereby elongating each image point into a line. These image lines coalesce, in the case of a spectral line, into a continuous dark line on which good position settings can be made. For star images the method is not applicable. Other methods may, how-

ever, be used that depend, in principle on a reduction in the resolving power of the imaging system. This reduction can be effected by producing first a minified image and then viewing the minified image through a microscope. For a given separation of the grains the necessary amount of minification to destroy resolution can be computed, for an objective of known numerical aperture, on the basis of the diffraction theory. The results obtained by this minification-magnification method are gratifying. The same method can be used to eliminate the grains in a half-tone print. Another method is to reduce the aperture of the observing microscope by means of an iris diaphragm in the rear focal plane of its objective. For spectral lines a slit aperture in place on the iris diaphragm decreases the resolving power along the spectral lines but maintains the full aperture of the objective normal thereto. For faint spectral lines the use of dark-ground illumination, obtained by placing a suitable central stop in a microscope condenser lens, is advantageous. In this arrangement the spectral lines appear as bright lines on a gray background. The observations may be made either in natural or in polarized light.

The present paper will appear in full in J.O.S.A. 15 min.

Saturday Afternoon, 2 o'clock

Columbia University, Physics Laboratory, Room 428

(For simultaneous session of the Physical Society, Room 401, see Program pages 21–24.)

CONTRIBUTED PAPERS

28. Herbert E. Ives — **Bell Telephone Laboratories**

METHODS OF PROJECTING PARALLAX PANORAMAGRAMS

The problem of projecting pictures to exhibit stereoscopic relief can be solved in either of two ways. (1) Projection upon any "ordinary" screen of two pictures, taken from two points of view, with provision *at the eyes of the spectators* of means for distributing separate views to each eye; (2) projection of two or more pictures, taken from different points of view, upon a screen so constructed that the distribution of the views to the spectator's eyes is brought about *by some special construction of the screen.* For the latter method to provide stereoscopic vision to any observer, wherever situated, it is necessary that the picture projected be a panoramagram[1], rather than a stereogram, that is, it must consist of an infinity of views.

Three forms of screen have been devised for projecting parallax panoramagrams. The first is built up of transparent rods with front and back convex cylindrical surfaces. The front surfaces are of such curvature as to accurately focus parallel rays upon the back cylindrical surfaces. The latter are given a diffusing finish, and the parallax panoramagram (as made by a moving lens camera) is projected upon them from the rear, each strip of the panoramagram accurately registered upon a rod. The screen then displays a stereoscopic image through a wide angle of observation.

The other two designs of screen are intended for use with panoramagrams made at a single exposure by means of a large lens or concave mirror. These pictures have the component elements in the panoramic strips so disposed as to give pseudoscopic instead of stereoscopic relief,[2] and are unsuited for projection on the first type of screen. In order to transpose the elementary strip images, optical screen elements are used which form virtual images of the projecting lantern lens. One such screen, for reflected light projection, consists of polished, horizontally ribbed cylinders, in which the reflected images of the lens appear as narrow lines of light each cylinder having one of the picture strips projected upon it. The other screen consists of concave cylindrical grooves cut in a sheet of transparent material such as celluloid. These grooves function for transmitted light in a manner similar to the reflecting cylinders just described.

Bibliography:

[1] J.O.S.A., Dec., 1928, p. 435.
[2] J.O.S.A., June, 1930, p. 332.

15 min.

29. Arthur C. Hardy and O. W. Pine — **Mass. Inst. Technology**

AN ANALYSIS OF THE ERRORS IN THE USE OF INTEGRATING SPHERES

An investigation is made of the errors resulting from the finite size of the sample and the illuminating and observing apertures in integrating spheres.

The present paper will appear in full in J.O.S.A. 10 min.

30. L. E. Dodd — **University of California**

ADAPTION OF ABBE REFRACTOMETER WITH COMPENSATING PRISMS FOR READING REFRACTIVE INDICES FOR ANY MONOCHROMATIC LIGHT

With a given liquid and the compensating prisms set for achromatism the scale of an Abbe refractometer customarily reads directly the index of refraction for sodium light. It is possible to read indices for any other available single wave lengths by setting the prisms at other than the achromatization reading if use is made of suitable calibration formulae. The situation is analyzed in the present paper. Such formulae both general and special are derived.

Bibliography:

Abbe, 1874.
Wien and Harms, 1929.

The present paper will appear in full in J.O.S.A. & R.S.I. 10 min.

31. Roger S. Estey — **Electrical Testing Lab.**

THE ISOLATION OF ERYTHEMAL RADIATION

The width of the transmitted band of a monochromator is controlled primarily by the exit slit and to a lesser extent by the entrance slit, while the abruptness of wave length cutoff is controlled primarily by the entrance slit and to a lesser extent by the exit slit. The shape of the transmitted curve can be definitely stated in terms of a slit factor defined by the relation

$$\text{slit factor} = \frac{\text{wave-length range transmitted with full intensity}}{\text{total wave-length range transmited}}$$

Assuming as an approximation, linear dispersion over the width of either slit, for slits set at the same width the slit factor can be shown to be $\frac{1}{3}$. This means that for any total wave-length range transmitted, the intensity rises uniformly from zero to a maximum during the first third of the wave-length interval, remains at a maximum over the second and returns uniformly to zero at the end of the interval.

This principle has been applied to the isolation of the region represented by the 2967A maximum of the erythema curve in the following way. Keeping the entrance and exit slits of equal width, the slit widths and wave-length adjustments of a monochromator have been set so as to bring the extreme limits of the transmitted band to the wave lengths 2900A and 3050A. This transmitted band so obtained was verified by a quartz spectrograph placed behind the monochromator. The similarity between the resulting transmission and the erythema curve is indicated in the following table.

Wave length	Monochromator Transmission	Erythema Response		
		Hausser & Vahle[1,2]		Luckiesh, Taylor and Holladay[3]
		1922	1927	
3342	0.00	—	0.00	0.00
3132	0.00	0.045	0.00	0.025
3024	0.58	0.58	0.70	0.35
2967	1.00	1.00	1.00	1.00
2925	0.55	—	—	0.25
2894	0.00	0.30	0.34	0.10
2804	0.00	0.28	0.063	0.04

[1] Hausser & Vahle, Strahlentherapie, *13*, 41 (1921).
[2] Hausser, Strahlentherapie, *28*, 25 (1928).
[3] Luckiesh, Taylor and Holladay, J.O.S.A., *20*, 423 (1930).

This method permits the integral value of erythemal radiation of any source to be obtained in one measurement and gives a much closer approximation to the erythema curve than do the usual filter methods. 10 min.

32. E. Q. Adams Lamp Development Laboratory, General Electric Company

AN ANALYSIS OF HAUSSER AND VAHLE'S DATA ON ERYTHEMA

The recent work on the function of ultraviolet irradiation in forming the antirachitic Vitamin D has awakened renewed interest in the health-giving properties of radiations of shorter wave length than the visible spectrum, and in photo-erythema, the reddening of the skin produced by exposure to such radiations.

Hausser and Vahle have published results on the erythemal effectiveness of mercury radiation. These have been analysed by the method customarily applied to the blackened photographic plate. In their results degree of erythema was determined by comparing the color of the reddened skin with dyed paper standards. The paper colored with the maximum concentration of dye corresponded in color to eighth degree erythema. One-half the concentration of dye gave seventh degree; one-quarter, sixth; one-eighth, fifth, etc., fractions of degrees being estimated. In this analysis it was found by trial that plotting the square root of dye concentration against logarithm of exposure producing the erythema gives lines straight within the experimental error. From such straight line relations the effectiveness of radiation of various wave lengths in producing different degrees of erythema has been determined.

In photographic work the plate density varies with time of development. In a somewhat analogous way, the degree of erythema varies with time after exposure, rising to a maximum and then subsiding, with or without pigmentation.

The foregoing results apply strictly only to the results of monochromatic radiation but by connecting points for the various wave lengths by a smooth curve they have been extended to sources of continuous radiation. No quantitative experimental work seems to have been done on combinations of two or a small number of different wave lengths and the results with very complex mixtures of radiation do not readily lend themselves to analysis. In default of experimental knowledge, in this analysis the "addition theorem" approximately valid in photographic work has been assumed for erythema: the "addition theorem" namely, that to produce any given density (degree of erythema) the ratios of the intensity at each wave length to the intensity necessary to produce the given density (degree of erythema)—when that wave length is acting alone—must sum up to unity.

20 min.

33. B. T. Barnes and W. E. Forsythe
Lamp Development Laboratory, General Electric Company

ERYTHEMA DUE TO ULTRAVIOLET RADIATION

The results of the analysis of Hausser & Vahle's erythema data given in the preceding paper by E. Q. Adams have been used to calculate for different sources the relative effectiveness of the radiation in different spectral regions and the total erythemal effectiveness. With a bare quartz mercury arc the lines at 2480 and 2537A are found to produce the major part of the effect for intensities of reddening ranging from the threshold to the third degree. For more intense erythema the lines in the neighborhood of 3000A are responsible for most of the action. When the intensities of the lines of wave lengths shorter than 2700A in mercury arc radiation are sufficiently reduced, as in the case of the General Electric and Uviarc Sunlamps, the lines at 2967 and 3024A are of most importance even in producing the threshold of erythema.

The erythema produced by radiation from a tungsten filament at 3024°K in a quartz bulb is largely due to ultraviolet of wave lengths between 2450 and 2600A when the reddening is very slight. With higher degrees of erythema the radiation in the neighborhood of 3000A produces the major part of the action. In either case the spectral distribution curves for the erythemal effectiveness have two maxima, one near 2537 and the other near 2967A. Radiation from the sun directly overhead (transmitted through one atmosphere) has its maximum erythemal effect at about 3060A but over one-half the effect is found to be due to radiation of wave lengths longer than 3100A. Taking as a unit the time necessary for the sun's radiation through one atmosphere to produce erythema of the first degree the exposures times for various other sources have been computed. Results are shown in the table below.

Relative Lengths of Exposure Necessary at 1 Meter Distance

Degree of Reddening	Sun through one Atm.	Sun through Window Glass	Bare Uviarc 72.5 V. 3.75 A.	G. E. Sunlamp	500 W. Lamp Quartz Bulb	500 W. Lamp Corex D Bulb
0	.90	—	.013	.28	6.4	35
1	1.00	22.	.065	.44	17.	50
4	1.31	—	.89	.90	82.	104

20 min.

34. G. Failla and P. S. Henshaw **Memorial Hospital, New York**

THE RELATIVE BIOLOGICAL EFFECTIVENESS OF X-RAYS AND GAMMA RAYS

Both x-rays and gamma rays are capable of producing certain biological effects. The relative amounts required to produce the same effect in a given medium depend first of all on the way in which quantity of radiation (usually called "dose") is defined and measured. The international unit of quantity of x-radiation, *the roentgen*, adopted in 1928 is based on ionization in free air. In practice to comply with the requirements of the definition of the roentgen, it is necessary to measure x-rays by means of a large ionization chamber through which passes freely a narrow pencil of rays.

Theoretically it is obvious that the roentgen can be used also as a unit of gamma radiation. However, the experimental procedure is fraught with many practical difficulties and so far no direct measurements of gamma rays in roentgens have been published. On account of the importance of the problem from both the theoretical and practical points of view, the authors have attacked this problem in the only way which is capable of giving unequivocal results—that is, by developing an apparatus which fullfils the requirements of the definition of the roentgen, without questionable assumptions.

Having done this it became possible to compare the biological effectiveness of equal doses of x-rays and gamma rays expressed in roentgens. As a biological test object wheat seedlings were used. Extensive experiments with this material had brought out previously several important advantages: (1) Simplicity of technique, (2) reproducibility of results with reasonable precision, (3) biological changes could be observed simultaneously in cells having widely different radiosensitivities, (4) time required between irradiation and observation of results is relatively short, (5) doses required to produce a measurable effect are not unduly large. Nevertheless in order to irradiate the seedlings both with x-rays and gamma rays under strictly comparable conditions it was necessary to use four grams of radium.

The results obtained cannot be summarized briefly but will be given in full in the paper.

The present paper will appear in full in *Radiology*.

20 min.

PROGRAM

For Sessions of The American Physical Society

FRIDAY MORNING AT 10 O'CLOCK

Columbia University, Physics Laboratories, Room 401

(For simultaneous session of the Optical Society see Program pages 5–6).

Papers No. 5, 6 and 8 will be read by title.

1. Water vapor absorption spectrum in the near infrared. E. D. McAlister, *Division of Radiation and Organisms, Smithsonian Institution, and* H. J. Unger, *University of Oregon.*—The 1.13, 1.38 and 1.45μ water vapor bands have been obtained with a self recording spectrograph using an effective slit width of 6A. The fine structure of the 1.13 and 1.45μ bands has been revealed for the first time and several lines have been added to the 1.38μ band. Forty lines appear in the 1.1μ region and eighty-five in the 1.4μ region. A comparison of these bands with similar ones due to atmospheric absorption in the solar spectrum identifies several superimposed solar lines. Regularities in frequency and intensity are lacking, due to the fact that a 6A slit is much too coarse to reveal the true structure of these bands.

2. Transmission of radiation through fog. S. Herbert Anderson, *Signal Corps Laboratories.*—A laboratory method for the production of fog was developed in which the processes of formation of natural fogs were closely simulated. Transmission of radiation through this laboratory-made fog was measured for a range of wave-lengths from 3000A to 26,000A. A wide range of fog densities was used corresponding to natural fogs in which the visibility varies from 5 meters to 500 meters. A minimum transmission was found in the visible spectrum, the position of the minimum being a function of particle size. From λ_{min} to $\lambda = 26{,}000$A the transmission increased, likewise from λ_{min} to $\lambda = 3000$A. The transmissions obtained have been used to test King's equation $I = I_0 e^{-(a+b\lambda^{-4})}$. This equation if found *not* to hold for transmission of radiation through fog, contrary to the conclusion reached by Granath and Hulburt (Phys. Rev. **34**, 140, 1929). The discrepancy is probably due, (1) to the difference in particle size, (2) the width of the bands in the infra-red used by Granath and Hulburt, (3) to the absorption of water vapor, the effect of which was eliminated in this work but not in Granath and Hulburt's.

3. The absorption spectrum of blood and its relation to rickets. R. C. Gibbs, J. R. Johnson and C. V. Shapiro, *Cornell University.*—The ultraviolent absorption spectra of solution, obtained by hemolyzing the red blood cells of healthy and rachitic rats, have been found to be identical. This result is contrary to that reported by Suhrmann and his co-workers, Phys. Zeits. **30**, 959 (1929), whose curves for the two sets of animals show a difference in intensity, which increases in the direction of shorter wave-lengths. Calculations based on Rayleigh's law of light scattering indicate that this difference can be attributed to the presence of an excess of a disperse phase in the solution whose absorption is the more intense. Experimental verification of this hypothesis has been obtained by measuring the absorption of one of our solutions after it had been centrifuged to remove most of the suspended matter. The new curve so obtained is less intense than the original and the difference increases toward shorter wave-lengths, in close accordance with the Rayleigh law. This evidence points to a physical cause for the variation reported by Suhrmann and renders unnecessary his improbable assumption of a chemical change in the hemoglobin. The discrepancy between his results and ours may be accounted for by assuming either that there are two types of rickets, possibly brought on by different diets, or else that the variation reported by him, especially in view of its physical origin, is due to some cause, not necessarily associated with rickets.

4. Energy distribution in the lunar ultraviolet spectrum. Brian O'Brien, *Institute of Optics, University of Rochester, N.Y.*—The energy distribution in the ultraviolet spectrum of sunlight reflected from the full moon has been measured from λ4400A to λ3020A, by the method

previously applied to direct sunlight. (Phys. Rev. **36**, 381 (1930)). Uniformity of slit illumination was secured by an astigmatic telephoto combination of quartz provided with rectangular stops, the measured spectral energy distribution being an average across a lunar diameter. Transmission coefficients and ozone content of the earth's atmosphere were obtained directly. The amount of ozone at night has been found to differ only slightly from the day values obtained on succeeding days in agreement with Chalonge and Götz (Gerl. Beit. z. Geophys. **24**, 20 (1929)). By comparison with direct sunlight the reflection coefficients for the moon's surface have been calculated throughout the above spectral region. No pronounced maxima or minima of reflecting power have been found within this range of wave-lengths. A test of some delicacy is thus provided, with negative results, for very small amounts of ozone (and hence oxygen) surrounding the moon.

5. Raman spectra of some organic halides. CLAUD EDWIN CLEETON AND R. T. DUFFORD, *The University of Missouri.*—Raman spectra obtained by helium excitation from nineteen organic compounds, several of which have not been studied previously, are reported and discussed. It has been found by one of the writers (C. E. C.) that in the cases of many simple organic halides the observed frequencies can be expressed as harmonics or combinations of four fundamentals (five in the cyclic compounds), two of which are not found in the Raman spectra, and are lower than predicted by any theory available, and hence may prove to be illusory; but the scheme does serve to point out certain regularities in these spectra. The bearing of such theory as is available is discussed.

6. Raman spectra and a slight asymmetry of the carbon and nitrogen atoms. R. T. DUFFORD, *The University of Missouri.*—The interpretation of the Raman spectra of the simpler organic halides and other related compounds is discussed; it is shown that most of the observed frequencies can be associated with vibrations of pairs or groups of atoms as predicted by theory, except that, in order to explain the multiplicity of certain lines, it seems necessary to assume a slight dissymmetry—i.e., a lack of equality of the valance bonds—of the carbon atom. Similar but less extensive evidence seems to indicate that the three valences of nitrogen are also not quite equally strong.

7. Vibrational quantum analysis of the ultraviolet SO_2 and CS_2 absorption bands. WILLIAM W. WATSON AND ALLAN E. PARKER, *Yale University.*—Analysis of spectrograms taken with a Hilger E-1 spectrograph shows that the SO_2 bands may be represented by the formula

$$\nu = 30586 + \{[381.1(v_1'+\tfrac{1}{2}) + 6.22(v_1'+\tfrac{1}{2})^2 - 0.223(v_1'+\tfrac{1}{2})^3] - [1381(v_1''+\tfrac{1}{2}) - 20(v_1''+\tfrac{1}{2})^2]\}$$
$$+ \{[436.7(v_2'+\tfrac{1}{2}) + 2.94(v_2'+\tfrac{1}{2})^2 - 0.199(v_2'+\tfrac{1}{2})^3] - [1157(v_2''+\tfrac{1}{2}) - 12.5\ (v_2''+\tfrac{1}{2})^2]\}$$

Noteworthy points are: positive quadratic term of the upper state levels, agreement with two of the fundamental frequencies determined by Raman and infra-red analysis, no evidence for the 606 cm^{-1} deformation frequency, and the existence of various addition series as given by the double formula. Apparently a triplet electronic level is involved. High dispersion plates do not resolve the rotational fine structure. Most of the bands of the CS_2 system are given by

$$\nu = 28880 + 215(v_1'+\tfrac{1}{2}) - 802(v_1''+\tfrac{1}{2}) + 270(v_2'+\tfrac{1}{2}) - 1466(v_2''+\tfrac{1}{2})$$

the anharmonic coefficients being nearly negligible. There is also evidence for a deformation frequency of 208 cm^{-1} in the ground state. Series of addition bands are found as for SO_2. The Raman frequency 655 cm^{-1} is the difference between the 1466 cm^{-1} and 802 cm^{-1} fundamental frequencies.

8. Paschen-Back effect and hyperfine structure in the spectrum of bismuth III. J. B. GREEN, *Ohio State University.*—A study of the spectrum of Bi in a field of 34000 gauss yields interesting data with respect to the hyperfine structure of Bi III. In particular, the line 4561, classified by McLennan as $^2P_{1/2}{}^2S_{1/2}$ gives 2.53 cm^{-1} for the ^2S separation, and 0.47 cm^{-1} for the $^2P_{1/2}$ separation. Several "forbidden" components appear on the plates. The line 3695, classified as $^2P_{3/2}{}^2S_{1/2}$ seems to indicate that the $^2P_{3/2}$ separation is much smaller.

9. Hyperfine structure in Bi II and Bi III. R. A. FISHER AND S. GOUDSMIT, *University of Michigan.*—The hyperfine structure of several lines in Bi II and III has been determined. The results form a partial confirmation of the classification given by McLennan, McLay and Craw-

ford (Proc. Roy. Soc. **A129**, 579 (1930)). It is possible to derive the hyperfine splitting for a number of levels. Together with the data on Bi I they form useful material for theoretical investigation. Bismuth is at present the only element for which hyperfine structure depending upon other than a single *s* electron is known for several levels.

10. Difficulties in the theory of hyperfine structure. S. GOUDSMIT, *University of Michigan.*—Sum rules and formulae for the hyperfine separations of the levels are derived for complicated configurations. The observed hyperfine structure of neutral and ionized bismuth, shows large deviations from the theoretical expressions. The nature of the discrepancies suggests that the present theory of the interaction between a single electron and nuclear spin is incomplete.

11. The theory of complex spectra II. E. U. CONDON AND G. H. SHORTLEV, *Princeton University.*—Formulas for the relations between the energies of multiplets arising from the same electron configuration for all two-electron configurations up to ff' and several cases of three-electron configurations have been worked out following Slater's method. A systematic comparison of the known data with this first-order perturbation theory shows only rough agreement in most cases although in a few there is excellent agreement. The theory predicts the observed alternation in the relative position of singlet and triplet through S, P, D, F, etc. in the pd and pf triads and the dd' and df pentads. For the d^2 configuration it was found that good fits are obtained except for the ^1S which theory indicates is much higher than the ^1S which spectroscopists assign to this configuration. The same is probably true for ^2S in d^2s.

12. The determination of heats of dissociation from predissociation spectra. LOUIS A. TURNER, *Princeton University.*—Two distinct types of predissociation spectra are known. In one the broadening of the lines begins suddenly at a definite wave-length, in the other it sets in gradually. Consideration of various possible relationships of potential energy curves suggests that the one or the other type occurs according to whether the curves for the two states concerned intersect below or above the energy of dissociation in the perturbing state, respectively. Accurate values of heats of dissociation can be obtained only from predissociation spectra of the first type. The others give merely upper limits. A predissociation of each kind is observed in the spectrum of NO_2 and the numerical relationships are in accord with the theory.

13. The inverse-cube central force field in quantum mechanics. G. H. SHORTLEV, *Princeton University.*—The problem of the motion of a particle in an inverse-cube central force field is fully treated by quantum mechanics and the results compared with the classical theory. Taking the effective radial potential energy as $(M^2/2\mu - S)/r^2$, one gets good correspondences between the quantum mechanical and classical solutions except for S between $l(l+1)\ h^2/8\pi^2\mu$ and $(l+\frac{1}{2})^2h^2/8\pi^2\mu$, where one gets a peculiar absence of oscillations in the ψ-function near the origin and somewhat poor agreements in regard to the radial probability functions. This is interesting in view of the uncertainty as to which value to compare with the classical angular momentum. However, the correspondence in allowed energies is complete only if the value $l(l+1)$ is taken. Solutions are found corresponding to the six classical types of orbits, with no quantization whatever. The solutions involve Bessel functions of both real and imaginary order with both real and imaginary arguments.

14. van der Waal's forces of helium and the stability of a small energy helium molecule. HENRY MARGENAU. *Yale University.*—Hopfield (Astrophys. J. LXXII, 133 (1930)) has recently postulated the existence of a He molecule of very low energy of binding. Theoretical evidence for the existence of such a molecule will here be given. The work consists of two parts. (1) A general method is outlined by which van der Waal's forces can be calculated without the knowledge of wave functions. Main features are. The expression for the interaction energy of 2 atoms in their lowest state is written in terms of the dispersion f-values, which are shown to be derivable with good approximation, by the aid of the "Summensatz" of Thomas and Kuhn, from the relative intensities of the resonance lines and the polarizability. The method is applicable to atoms (and molecules) more complex than He. Results for He:

$$\Delta_2 E = 11.28/R^6 \times 10^{-61} \text{ ergs}, \quad R > R_0.$$

(2) From the potential energy curve given by this expression and $\Delta_2 E = +\infty$ for $R < R_0$, R_0 being

taken as 2.33×10^{-8}cm, the vibrational states for the resulting molecule are computed. Results: Minimum of potential energy $= -10^{-14}$ ergs; the molecule has but one vibrational state of energy about 3.3×10^{-16} ergs $= 0.2$ millivolts, which is in qualitative agreement with Hopfield's predictions

FRIDAY MORNING AT 10 O'CLOCK

Columbia University, Physics Laboratories, Room 329

(For simultaneous session of the Optical Society see Program pages 5–6).

15. Group theory and the electric circuit. NATHAN HOWITT, *Naval Research Laboratory Bellevue, D. C.* (*Introduced by Elias Klein*).—The paper shows that electrical networks consisting of inductances, resistances, and capacitances form a group with the impedance function as an absolute invariant. That is, to a given impedance function there corresponds an infinite number of networks, any one of which can be obtained from any other by a special linear transformation of the instantaneous mesh currents and charges of the network. In this manner one may arrive at the complete infinite set of networks equivalent to a given network of any number of meshes. This is done by writing down the three fundamental quadratic forms of the network. Then a linear affine transformation of the instantaneous mesh currents and charges of the network results in the formation of new quadratic forms, the matrices of the coefficients of which represent a member of the group, i.e., an equivalent network. Instead of performing the substitutions, the three matrix multiplications $C'AC$ are used, one for each quadratic form, where A represents the original matrix, C the transformation matrix, and C' its conjugate. It may be possible to extend this theory to include continuous systems where the quadratic forms become integrals or infinite series and one deals with infinite matrices and infinite transformations.

16. Magnetic lag at low flux densities. L. W. MCKEEHAN, *Yale University*.—Energy losses in alternating magnetization are often compared by assuming that H and B vary sinusoidally, B lagging by an angle ϵ. At low flux densities ϵ is not fully accounted for by calculated eddy current and hysteresis terms if each branch of the hysteresis loop is assumed parabolic with least slope equal to that at the origin of the normal magnetization curve. The residue, ϵ_n, is a true magnetic lag. No explanation for it has hitherto been offered. It is now pointed out that Barkhausen discontinuities involve a magnetic lag which may suffice to explain the existence of ϵ_n. For example, 600 equal discontinuities per half cycle would suffice if $\epsilon_n = 10^{-3}$. The necessary mean magnitude of these discontinuities is improbably great unless it is principally strained regions which are affected by weak applied fields. If Jordan, Zeits. f. techn. Physik **11**, 2–8 (1930), is right in supposing that ϵ_n is independent of H_{max} over the small range in which it can be measured with any precision, the average magnitude of the discontinuities would have to vary directly with H_{max} throughout this range. This is not inconsistent with the parabolic form of (smoothed) magnetization curves at low flux densities.

17. Ferromagnetism of dilute solid solutions. FRANCIS BITTER, *Westinghouse Elec. & Mfg. Co., East Pittsburgh*.—Since the atoms of the solvent are known to move about in the solute it is possible to consider annealed and aged solutions as systems in thermodynamic equilibrium. It is shown that the strains set up by the atoms of solvent in the solute do not produce long range forces. There are, then, no long range repulsive forces tending to produce a microscopically uniform distribution. Under these circumstances the fluctuations in density of the solute will be at least as large as those in a perfect gas, and may become much larger (as large as those giving rise to opalescence, for instance). Local concentrations or rarifications of impurities may play an important part in determining magnetic properties through the inhomogeneities and strains they set up. For instance, in the iron-carbon diagram, the observed magnetic transformation of Austenite at 770°C would necessitate a drastic revision of ideas about ferromagnetisms if it were granted that Austenite is a solid solution of carbon in γ-iron. If, however, it is assumed that Austenite contains small inclusions of α-iron where there are local rarifications of carbon concentration, the difficulty disappears. Whether Austenite contains α-iron at 770°C should be determined by x-ray investigations. It is further suggested that the magnetic properties of dilute solutions of ferromagnetic substances in other metals are largely determined by local concentrations of ferromagnetic atoms.

18. Capillary rise in sands of uniform spherical grains. W. O. SMITH, PAUL D. FOOTE, AND P. F. BUSANG, *Gulf Research Laboratory, Pittsburgh.*—Uniform spheres packed in regular array form a non-cylindrical cyclic capillary, characterized by a maximum and minimum capillary rise with intermediate positions of possible equilibrium. In practice spheres may be packed to a variety of porosities P thus requiring a mixture of regular and irregular piling arranged in a very distorted pattern. However the meniscus is also distorted to conform in a general way with the distortions of the lattice. Accordingly positions of maximum and minimum rise may be expected. The meniscus for maximum rise tends to pass through the plane of centers of neighboring spheres. Slight deviations from this condition due to the rise at sphere contacts are shown to be of minor importance. Any piling may be treated statistically as a hexagonal array with a spacing $2r+d$ where d is computed to give the observed porosity. In such a system three types of cell occur with a definite frequency, and these cell types are assumed present in the meniscus with the same frequency distribution. Hence it is possible to evaluate $pr/a=\rho ghr/\sigma$ where p=perimeter, r=grain radius, a=area of pore opening, g=accelation of gravity, σ=surface tension, ρ=density and h=capillary rise. The final formula so derived reduces to

$$\frac{pr}{a}=\frac{\rho ghr}{\sigma}=\frac{2}{\frac{0.9590}{(1-P)^{2/3}}-1}$$

This agreed with experiments made with several sizes of grains, porosities, and liquids. The minimum rises were also determined but a satisfactory interpretation in terms of a model has not been effected.

19. The variation of the thermal boundary layer of a miniature airfoil. MERIT SCOTT, *Gugenheim Research Physicist, Cornell University.*—By mounting thin, narrow conducting strips parallel to the span of an airfoil, and flush with its surface, it is possible, experimentally, to measure a thermal dissipation coefficient, p_e, associated with a particular location on the lifting surface, as well as its variation with velocity and angle of attack, α. Such measurements have been accomplished with a velocity range of 12 to 24 m/sec and for angles of attack varying from $-40°$ to $+35°$. It is found that p_e, independent of position on the surface, is a linear function of the velocity at the strip. Curves, showing its variation with angle of attack, present definite maxima and minima, characteristics which bear no direct correspondence to the velocity at the strip. It was to be expected that the variation of p_e, at a given location, with angle of attack would be of the same character as its variation with position along the chord. This is experimentally verified. Theoretical considerations suggest converting this coefficient to boundary layer thickness, B, and interpreting this thickness as identical with the viscous boundary layer. The measurements have been extended over the wide range of angle of attack so that the relation of these quantities to the useful range of the airfoil might be studied.

20. The variation of C_p of Oxygen and Nitrogen with pressure at 26° and 60°C. E. J. WORKMAN, *National Research Fellow, Bartol Research Foundation.*—By the use of improved apparatus of the type previously described by the author (Phys. Rev. **36**, 1083 (1930)) the ratio of C_p at a pressure 1° to C_p for the same gas at a pressure of one atmosphere is determined. Oxygen and nitrogen gas have been studied at 20 and 60°C on the pressure range 10 to 130 Kg per cm². Values of the ratio as measured may be inferred from smooth curves drawn through the points plotted from the data in the table below, where the pressure is given in Kg/cm².

Oxygen, 26°C		Oxygen, 60°C		Nitrogen, 26°C		Nitrogen, 60°C	
Pressure Kg/cm²	Ratio $C_p's$	Pressure Kg/cm²	Ratio $C_p's$	Pressure Kg/cm²	Ratio $C_p's$	Pressure Kg/cm²	Ratio $C_p's$
1	1	1	1	1	1	1	1
30	1.0520	30	1.0375	30	1.0443	30	1.0324
60	1.1065	60	1.0768	60	1.0900	60	1.0665
90	1.1635	90	1.1163	90	1.1332	90	1.0990
130	1.2410	130	1.1680	130	1.1863	130	1.1395

FRIDAY AFTERNOON AT 2:30 O'CLOCK

Columbia University, McMillin Theater

Joint Session of the American Physical Society and the Optical Society of America

SYMPOSIUM

on

"Physical Problems Related to the Biological Effects of Radiant Energy."

Invited Papers

21. Some Physiological Effects of Light. Brian O'Brien, *Institute of Applied Optics, University of Rochester.*

22. The Spectra and Anti-Rachitic Potency of Various "Therapeutic" Lamps. Harvey B. Lemon, *University of Chicago.*

23. Methods of Measuring Radiant Energy. Harold W. Webb, *Columbia University.*

SATURDAY MORNING AT 10 O'CLOCK

Columbia University, Physics Laboratories, Room 401

(For simultaneous session of the Optical Society see Program pages 6–10)

24. X-ray measurements of the elastic deformation of metals. William P. Jesse, *The General Electric Company.*—The metal wire to be tested lies along the axis of a precision x-ray camera. A series of photographs is taken with various loads on the wire. On the photograph only the lines are measured where the resolving power is a maximum, i.e., where the incident angle θ is almost 90°. As the load on the wire increases, these high order lines shift in the direction indicating smaller grating spaces. This shift measures the contraction of the crystal lattice in a direction perpendicular to the direction of stress. For duralumin wire this contraction is in approximate agreement with the value calculated from the macroscopic Young's modulus and Poisson's ratio for the material. Similar results have been obtained with steel piano wire.

25. A new x-ray tube based on the "transparent target" principle. Dimitry E. Olshevsky, *Yale University.*—A new "transparent target" x-ray tube is described in which the portion of x-rays transmitted through the target is utilized. It is found that by using a properly designed, thick, double layer target in contradistinction to the thin single layer targets used by Owen and by Coolidge satisfactory heat dissipation may be secured at comparatively little sacrifice due to absorption. The new tube has a target made of a thick layer of low atomic number metal, backing a thin layer of high atomic number metal, in thermal contact with the former. A simplified theory of heat dissipation from the cathode spot is developed and a table is given, showing merits of various target materials as functions of wave-length. Important advantages of the tube over the conventional Campbell-Swinton arrangement are: proximity of the cathode spot to the outer surface of the tube, and the possibility of utilizing x-rays in the direction of the initial electron beam. As applied to crystallographic purposes, vertical beam models were built in which the first slit of the spectrograph is defined by a hole drilled in the body of the tube immediately behind the target. This arrangement permits higher intensities at the second slit on

account of a shorter slit distance from the cathode spot. Both slits are made integral with the tube, the whole arrangement possessing complete symmetry around the vertical axis. This vertical design, with the beam directed upwards, complete shielding of the tube proper and high tension leads concealed in a grounded table, contributes to the safety and comfort of work and is valuable for x-ray studies involving the liquid state. Special tubes based upon the new principle may prove of value for medical purposes.

26. New *K* series x-ray lines. WILLIAM DUANE, *Harvard University.*—*K* series x-rays have been examined by means of a Bragg spectrometer, the Moseley photographic method being employed. The incident ray and that reflected by the crystal to the photographic plate through distances of 4725 mm passed through long metal tubes, exhausted of air in order to reduce the absorption. The K_β doublet lines of molybdenum ($\Delta\lambda = 0.00056$A), examined by photometric curves, appear separated 0.88 mm. No third line lies in the immediate neighborhood of the β doublet. Between the γ line and the short wave-length limit of the series appears a marked blackening that represents several lines close together. They are not in the position of a line reported by Leide. The new lines may be due to 0 electrons falling into the *K* level, but a better explanation is, perhaps, that the lines are produced by falls into the *K* level of conductivity electrons which may from time to time lie in outer atomic energy levels. Several photographs produced by long exposures show a fainter single line, roughly halfway between the β_2 and the γ lines. It does not correspond to a known x-ray line of any chemical element reflected in the first or second order.

27. Electron diffraction by a silver crystal. H. E. FARNSWORTH, *Brown University.*—A previous investigation of electron diffraction by a copper crystal, for normal incidence on a (100) face (Phys. Rev. **35**, 1131 (1930)) revealed a series of weak beams requiring unit refractive index, in addition to the more intense beams requiring refractive indexes greater than unity. These weak beams are in most cases so close in voltage to the main beams that they appear as components or satellites of them. A similar series of measurements for two silver crystals shows, in general, the same to be true for silver, although certain beams have more complex structures containing additional components. In many cases the different components are extraordinarily sharp and intense. These results for low-velocity electrons suggest a complex variation of the inner potential near the surface of the metal.

28. Radiation from low speed electron bombardment of metals. F. L. MOHLER AND C. BOECKNER, *Bureau of Standards.*—A small probe surface at a positive potential in a discharge may draw a current of many amperes per cm^2 with the potential gradient limited to a thin sheath over the surface. Under such conditions a continuous spectrum is emitted by metal surfaces in caesium, potassium, and helium discharges. With a copper probe at 7 volts in caesium vapor, the intensity J remains of the same magnitude between 6200A and 2400A with a minimum at 5800 and a maximum at 3800. Below 4 volts the spectrum has a high frequency limit in this range (3000A for copper at 2.15 volts). On the assumption that this is analogous to a continuous x-ray spectrum, observed limits indicate work functions of 1.95 for Cu, 2.1 for Ag, 1.45 for W (all in caesium vapor). The absolute intensity (except for Ag) agrees within a factor of 2 with values computed from the theoretical equation for intensity of the continuous x-ray spectrum. Efficiency for Cu at 7 volts is estimated as 3×10^{-7}. Comparison with published data on photoelectric effect of radiation from electron bombardment of metals indicates that the magnitude of effects below 10 volts can be explained by this continuous spectrum.

29. The distribution of electricity near the surface of contact of two conductors. A. T. WATERMAN, *Yale University.*—Two dissimilar metals are postulated in contact along an infinite plane, and the equilibrium distribution of electricity is sought in a direction perpendicular to this plane on the basis of Sommerfeld's electron theory using Poisson's equation and the Boltzmann principle. The problem is solved under the assumptions that the potential and the electric intensity are continuous across the boundary, and that the P.D. between points in the two metals far from the boundary is equal to the contact P.D. In general, if the normal concentration of conducting electrons is assumed to be one per atom the electrons in both metals remain in the degenerate state, though their concentration may vary from normal by 30 to 50 percent at the boundary. In this case the distribution is unaffected by temperature. In this

special case of a pair of metals with high contact P.D., such as Cs and W, the electrons near the boundary in the more electropositive metal are reduced to the classical state and the distribution is a function of temperature. The possible bearing of these results upon the properties of thin metallic films is discussed.

30. An estimation of patch sizes on a thoriated tungsten filament. LEON B. LINFORD, *National Research Fellow, Princeton University.*—It is well known that coated filaments fail to follow Schottky's equation for thermionic emission in strong accelerating fields. Becker and Mueller (Phys. Rev. **31,** 341 (1928)) showed that the emission from thoriated tungsten is what would be expected if the surface fields were much larger than image fields at distances greater than 10^{-5} cm from the surface. These fields were confirmed by the author using the photoelectric method (Phys. Rev. **36,** 1100 (1930)). One explanation assumes that these large fields are due to a non-uniform surface distribution of positive ions. If these patches are assumed to be square and of dimension b, arranged checkerboard fashion with a contact potential difference V_0 between adjacent patches, the field above the center of a more positive area can be calculated. Using two values of the observed ion field the size of the patches was found to be about 2×10^{-4} cm, with about 0.5 volts contact potential difference V_0. The sum of the field produced by such a charge distribution and the image field was within experimental error of the observed field. From the surface field, and the threshold at a known accelerating field, the work function at zero field was found to be 2.7 volts or 1.8 volts less than that of pure tungsten.

31. Some thermionic properties of barium films absorbed on tungsten. HERBERT NELSON, *RCA Radiotron Company, Harrison, New Jersey (Introduced by G. R. Shaw)*—The activity and the change in contact potential difference have been studied as a function of the thickness of the barium film. The velocity distribution of the electrons, the effect of non-uniformities in the film, and the effect of field intensity on the activity have also been studied. The experimental tube was constructed such that the measurements could be made on a small area of the filament in order that errors due to lead losses, non-uniformities, and voltage drop along the filament might be minimized. A vacuum tube electrometer was used in measuring the electron currents. The experimental results obtained by Eglin were confirmed, i.e., the activity of the composite surface was found to increase with the thickness of the barium film until an optimum thickness was reached after which further deposit caused the activity to decrease. A relation such as derived by Richardson was found to exist between the thermionic constants and the contact potential difference. The distribution of velocities of the emitted electrons were found to be Maxwellian for all thicknesses of the barium film. The presence of non-uniformities in the emitting surface had the effect of decreasing the slope of the Maxwellian distribution curve.

32. Time changes in oxide-coated filaments. E. F. LOWRY AND W. T. MILLIS, *Westinghouse Electric and Mfg. Co., East Pittsburgh.*—The oscillograph is made use of in studying time changes in the electron emission of oxide-coated filaments. The decay of emission with time while drawing current is compared with rate of recovery when instantaneous measurements are made. It is found that similar phenomena, though of much less magnitude, occur when thoriated tungsten or bariated filaments are used. It has also been found that this fading effect is not a universal characteristic of oxide filaments though it is present in greater or less amount in the majority of instances. Oscillograph methods have also been employed in studying oxide emission at normal operating temperature.

SATURDAY AFTERNOON AT 2:00 O'CLOCK

Columbia University, Physics Laboratories, Room 401

(For simultaneous session of the Optical Society see Program pages 10–13).

Paper No. 35 will be read by title.

33. Grid current required by hot-cathode, grid controlled mercury arcs before discharge. W. B. NOTTINGHAM, *Bartol Research Foundation.*—The hot-cathode, grid-controlled mercury arc or "thyratron" has been described by A. W. Hull, (G. E. Rev. **32,** 213 and 390 (1929)). Al-

though the thyratron has been called "an electrostatically controlled arc rectifier," a definite grid current is required in the grid or control circuit. With a d.c. plate potential, this grid current, before the discharge begins may have any value from 6×10^{-3} amp. to -10^{-7} amp. depending on the type of thyratron, the plate potential and the mercury condensation temperature. In certain cases, the temperature enters so drastically that a change in ambient temperature of only a few degrees can cause the thyratron to fail to operate. With 60 cycle a.c. plate and grid potentials, experiment seems to show that 0.001 second is required to set up conduction in the thyratron. A time lag of this amount was unexpected. A comparison of the "phase shift" and "critical potential" methods of controlling a thyratron with photoelectric currents showed that for extremely small light intensities, the critical potential method is the more sensitive, although for greater light intensities the phase-shift method is perhaps more reliable. Satisfactory operation using either method of control was obtained with 10^{-18} amp. photoelectric current (approx. 3×10^{-4} lumen). The measurements were made on General Electric FG-17; FG-27 and FG-67 thyratrons.

34. A further study of galvanoluminescence. ROY RICHARD SULLIVAN WITH R. T. DUFFORD, *Bell Telephone Laboratories and The University of Missouri.*—Previous work by one of the writers has been checked and extended in several directions. The glow surrounding aluminum anodes was studied in several new solutions, as well as those already described. Several-fold larger efficiencies have been obtained by using water-cooled electrodes. Study of the glow seems to be against the theory of a gas film covering the electrode; the spectrum of the glow is a typical luminescence spectrum, and the brightness and efficiency lie in the same range as for other luminescent reactions under study in this laboratory. In many cases, the law of increase of brightness with voltage seems to have closely the same form as for a tungsten filament. The spectrum of the sparkles which appear at higher voltages is, however, a bright-line spectrum; the two strongest lines coincide with the strongest lines in the spark spectrum of aluminum. The glow surrounding various metals in ether solutions of Grignard reagents and of $MgBr_2\cdot 2(C_2H_5)_2O$ has been studied, giving the highest efficiencies so far found in this type of luminescence. Systematic differences between chemical groups of metals are found. The work was done at the University of Missouri.

35. Intensities of the magnetic and electric illumination components in the electrodeless discharge. CHAS. T. KNIPP, *University of Illinois.*—Recent theory (J. T. Tykociner and J. Kunz, Chicago Meeting, American Physical Society, November 1930, paper No. 5) indicates that a considerable portion, perhaps even 80 or 90 percent of the illumination in the electrodeless discharge is due to the electrostatic field. A discharge vessel was constructed experimentally to test this point. Obstructions were set in it with the idea that each type of discharge would cast its own shadow. With the most favorable conditions for a discharge passing due wholly to the magnetic field, shadows were obtained in the plane of the exciting coil which extended one-third way around the tube, while there were no indications of shadows at right angles, i.e., in the direction of the electrostatic field. By placing a band conductor to the right and to the left of the medial line, and removing the energizing coil entirely, a powerful electrostatic field was produced and shadows in this direction were now readily obtained, but the characteristic ring discharge was gone. Hence it appears, when conditions are favorable for the formation of *ring discharges*, that the intensity of the attending illumination is in part, if not entirely, due to carriers moving in the plane of the energizing coil. This result seems to support the calculations of Sir J. J. Thomson.

36. High frequency behavior of a plasma. LEWI TONKS, *General Electric Company, Schenectady, N. Y.*—Earlier work on spontaneous short-wave oscillations in a low-pressure mercury arc plasma (Phys. Rev. **33,** 195 (1929)) has been extended to forced oscillations by experiments similar to those of H. Gutton (Ann. de Physeque **13,** 62 (1930)). Theory gives $K=1-\nu_e^2/\nu^2$, where ν is the impressed, ν_e $(=8980\ (N_e)^{1/2})$ the plasma-electron frequency, for the specific inductive capacity of a plasma. The unit cube thus behaves like a tuned shunt circuit $C=\frac{1}{4}\pi$, $L=m_e/N_e e^2$. This disagrees with Gutton's conclusion. A modified Mossotti theory requires that a cylindrical plasma between plane condenser plates show shunt resonance when $\nu_e=(2)^{1/2}\nu$. With a constant impressed frequency, the positive column of a Hg arc al-

ways resonated at two values of arc current (ionization density) and sometimes at three, due possibly, to the non-uniformity of the plasma cross-section. The two main resonance densities were roughly in the ratio 2 to 5 and lay above and below the theoretical value. The variation with frequency was $\nu_e \propto \nu^{1.1}$ cf. $\nu^{1.0}$ theoretically. Above resonance ($\nu_e > (2)^{1/2}\nu$) the variation of K with ν_e as given above was confirmed.

37. Oscillations and travelling striations in an argon discharge tube. T. C. CHOW, *Princeton University.* (*Introduced by* H. D. SMYTH).—Oscillations of audible frequencies in an argon discharge tube with a long positive column were observed in a pressure range 0.06 to 4.2 mm Hg. The amplitude of the fluctuation of voltage across discharge tube is of the order of magnitude of 10 volts. Only in a certain portion of that region distinct travelling striations were observed. The flash frequency, defined as the number of striations passing across a certain cross-section per second was approximately equal to the frequency heard in a telephone receiver attached to the circuit. It was found to depend on conditions in the circuit, such as current, external resistance, inductance, capacity, and filament current. The space potentials in the tube were also found to fluctuate. Tonks and Langmuir have described a kind of electric sound waves, possible if a certain condition involving electron temperature and concentration and the wave-length of the sound waves is satisfied. This condition was satisfied in our experiment. From their expression for the velocity of electric sound waves and the experimentally determined flash frequencies a set of wave-lengths were calculated most of which are integral or half-integral multiples of the length of the discharge tube.

38. The fall of potential in condensed discharges. J. C. STREET, *University of Virginia.*—The fall of potential in the initial stages of discharges has been studied by utilizing the well-known fact that an electric pulse on a wire when reflected from an open end of the wire has its maximum potential doubled at reflection, provided the length of the pulse is not greater than twice that of the wire. Transient electric pulses produced by the condensed discharge under investigation traveled along two parallel, symmetrical, straight wires to their open ends where they were reflected. The maximum potential across the open ends was measured as a function of the length of wire from the spark gap by two independent methods and was found to decrease when the lead wires became a few meters in length. From this curve the rate of potential fall can be obtained directly by electric circuit theory. In the case of static sparks at atmospheric pressure, where the potential was slowly applied, a comparatively slow fall of potential (6% in 2×10^{-8} sec.) was obtained at the beginning, but a very rapid (94% to $1/e$ of value in 10^{-8} sec.) fall later. This result is in fair agreement with the results obtained by Rogowski and Klemperer (Archiv. f. Electrot. **24,** 127 (1930)) using a different method. When the pressure in the spark gap was decreased the rate of fall of potential in the initial stages was decreased. The method gives an easy way of studying the fall of potential in various kinds of discharges and is free from certain objections inherent in other methods. Such measurements, aside from giving information concerning the electrical breakdown itself, are desirable for a complete understanding of the operation of Kerr cells and cathode-ray oscillographs.

39. The Kerr electrooptical effect in gases. E. C. STEVENSON AND J. W. BEAMS, *University of Virginia.*—The electric double refraction or Kerr electrooptical effect in CO_2 has been studied as a function of the density and the temperature. The method previously reported (Phys. Rev. **35,** 1440 (1930)) and O.S.A. program Oct. 31, 1930) has been refined so that the temperature of the Kerr cell can be set and maintained to 0.05°C. The average deviation of the Kerr constant per molecule was found to be less than 2 percent throughout the density range from 0.08 to 0.18 grams per cubic centimeter when the temperature, electric field, and wave-length band (4700A to 4300A) were kept constant. Holding the density, electric field and wave-length fixed the Kerr constant per molecule was observed to increase with decreasing temperature. Our preliminary results show that this increase was approximately 10 percent for a temperature change from 45°C to 20°C which is in rough agreement with what might be expected from theory.

40. On the correlation of radio reception with the position of the Moon in the observer's sky. HARLAN T. STETSON, *Ohio Wesleyan University.*—Observations of the intensities of radio

reception at the Perkins Observatory and elsewhere have been utilized for a study of correlation of signal strengths with cosmic phenomena. Papers already published by the writer and by Greenleaf W. Pickard call attention to apparent change in the altitude of the Kennelly-Heaviside layer with the change in solar activity. The same data have now been utilized in an investigation of the possible relation between the intensity of signal strength and the position of the moon with respect to the observer, on the assumption that the moon is at a different electrical potential from that of the earth. The result of the observations indicates that the height of the Kennelly-Heaviside layer is substantially decreased by the presence of the moon above the horizon, and elevated as the moon passes underneath the observer. A plausible explanation follows on the assumption that the moon is negatively charged with respect to the earth. The form of the curve showing correlation between the moon's altitude and the intensity of radio reception suggests an electronic tide which follows a hypothetical equipotential surface in the electrostatic field of the earth-moon system.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for at any session in the Case School Physics Lecture Room after the completion of the regular program for the session.

41. Optical dispersion of helium. HENRY MARGENAU, *Yale University.*—The numbers of dispersion electrons (*f*-values) for helium calculated from Hopfield's intensity data by the semi-empirical method outlined in the author's first paper in this bulletin are used to construct an optical dispersion formula. Attention is to be called to the fact that transition matrices, computed from intensities of emission lines, are subject to considerable error. Nevertheless, the dispersion formula thus obtained, in which none of the constants are adjusted in the usual fashion, shows satisfactory agreement with the experimental data on the refractive index. The theory of molecular forces is extended to a calculation of dissociation potentials and vibrational levels of the molecules Hg-rare gas, observed by Oldenberg.

42. Intensities in the ultraviolet spectrum of mercury. E. D. MCALISTER, *Division of Radiation and Organisms, Smithsonian Institution.*—The intensities of the major spectral lines in the region 2000 to 4000A from a mercury vacuum arc have been measured. A quartz double monochrometer and vacuum thermocouple were employed. The effective slit width was 2A at 2100A increasing to 12A at 4000A. The 2537 line gave a deflection of 50 mm with a 4A slit width. The intensities of the first four "sharp" triplets are quite close to the theoretical 1–3–5 rule.